Physical Mechanisms of Thermal-Diffusivity Depth-Profile Generation in Hardened Steels Reconstructed by Photothermal Radiometry

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It is well established that thermophysical properties of steels can be used to probe the effects of industrial hardening processes. In hardened steels thermal-diffusivity broadly anticorrelates with microhardness, allowing thermal-wave depth profilometry to be used as a tool to measure microhardness profiles. Nevertheless, the physical mechanisms for this anticorrelation have not been well understood. In this talk, the thermal-diffusivity profiles of rough, hardened industrial steels reconstructed after the elimination of roughness effects from the experimental data will be presented as an application of an inverse thermal-wave problem using the generalized concept of the thermal-wave harmonic oscillator. Two possible approaches for eliminating surface roughness in the thermal-wave frequency response of inhomogeneous solids have been developed and will be discussed. Carburizing, carbonitriding and quenching are widely used for the heat treatment of steel components, and it is important to understand their effects on thermal-diffusivity profiles. A thorough examination of the actual mechanism by which thermal-diffusivity depth profiles are affected by first carburizing and then quenching AISI-8620 steels will be presented. Furthermore, similar examinations of carbonitrided (or carburized) and quenched AISI-1080 steels will be discussed. Conclusions on the effect of carbon concentration profiles and microstructural phase changes as possible mechanisms of variations of thermal diffusivity with depth will be drawn.